

WEEK SIX

ENERGY GENERATION

The total energy generated by 1 mole of pyruvic acid is 8 ATP. After glycolysis and TCA, a net total of 38 ATP would have been produced. After glycolysis and TCA, a net total of 38 ATP would have been produced.

| Pathway | Reaction catalyzed by | Method of production | No of ATP formed per mole of Glucose |
|-------------------|--|--|--------------------------------------|
| Glycolysis | Glyceraldehyde-3-phosphate dehydrogenase | Respiratory organ of Oxidation of 2NADH | 6 |
| | Phosphoglycerate kinase | Oxidation at substrate level | 2 |
| | Pyruvate kinase | Oxidation at substrate level | 2 |
| | Reaction catalysed by hexokinase | Phosphorylation reaction | -1 |
| | Phosphofructokinase | Phosphorylation | -1 |
| | | Net Total | 8 ATP |
| TCA | Pyruvate dehydrogenase | Respiratory chain of oxidation of 2NADH | 6 |
| | Isocitrate dehydrogenase | Respiratory chain of oxidation of 2NADH | 6 |
| | α -Ketoglutarate dehydrogenase | Respiratory chain of oxidation of 2NADH | 6 |
| | Succinate thiokinase | Oxidation at substrate level GTP | 2 |
| | Succinate dehydrogenase | Respiratory chain of oxidation of 2FADH ₂ | 4 |
| | Malate dehydrogenase | Respiratory chain of oxidation of 2NADH | |
| | | Net Total | 30 ATP |

LIPIDS METABOLISM

Series of reactions that occurs in the body are called pathways. They are processes by which the cell regulates itself, various myriad of enzymes that catalyse chemical reactions that take place in living cells are referred to as metabolism.

Metabolism therefore is the totality of chemical reactions in living matter. Metabolism has specific functions.

1. Metabolism obtain chemical energy from degradation of energy nutrients from the environment or from captured solar energy.
2. To convert nutrient molecules into building block precursors of cell macromolecules.
3. To assemble this building block into protein, nucleic acid, lipid, polysaccharides and other cell components.
4. To form and degrade bio-molecules required in specialized functions of cell.

Metabolism consists of 2 major pathways namely:

Catabolic (degradation) pathway

Anabolic (Biosynthesis) pathway

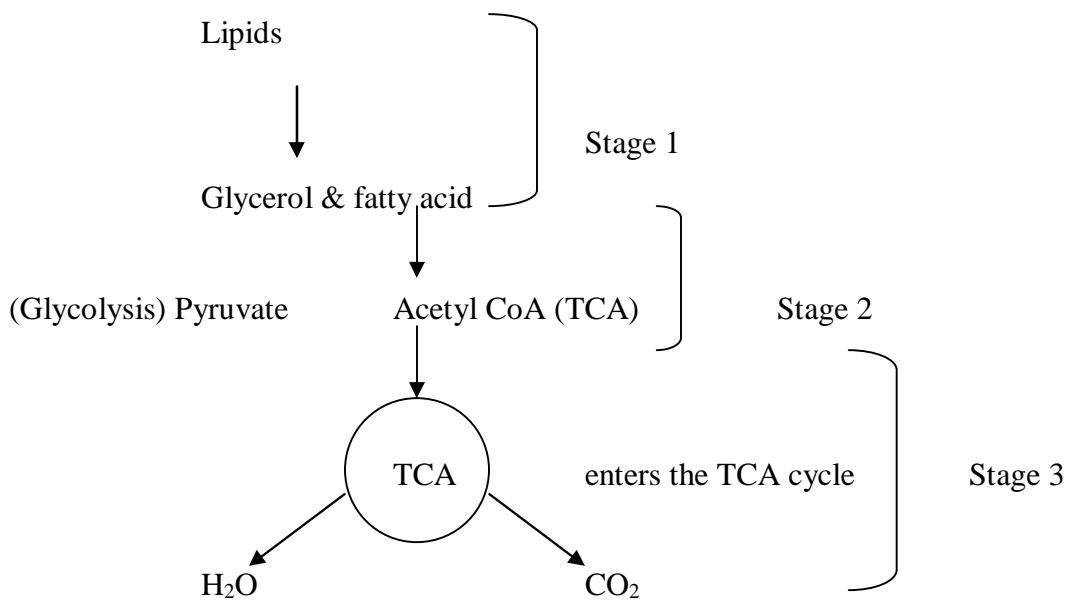
Anabolic takes place in 3 stages beginning with small precursors. Acetyl CoA are built up with fatty acid which are in turn assembled to form lipids.

Catabolism is a converging process, since it begins with few simple precursors from which large varieties are made.

REGULATION OF METABOLIC PATHWAY

The regulation of metabolic pathway is brought about by 3 different types of mechanisms;

1. Through the allosteric enzyme
2. By hormonal regulation
3. By concentration of a given enzyme on the cell.



Catabolism of lipids is divided into 3 stages.

In stage 1, hundreds of lipids are broken down into their building blocks which are few in number. Lipid in most organisms are in the form of tri-acyl glycerol. The term fat refers to this most abundant class of lipids. Triacyl glycerol plays no other role than energy storage. Most of the energy derived from fat comes from the oxidation of the constituent fatty acids. The brain is the only tissue that is unable to use fatty acid as a significant energy supply. However, under conditions of starvation and long fasting, the brain can adjust to use lipid related compounds like ketone bodies.

In stage 2, the building block molecules are further degraded into common products acetyl CoA and pyruvate.

In stage 3, the cell catabolism converge into the TCA cycle with the formation of 2 major products water and CO₂.

FAT DIGESTION AND ABSORPTION

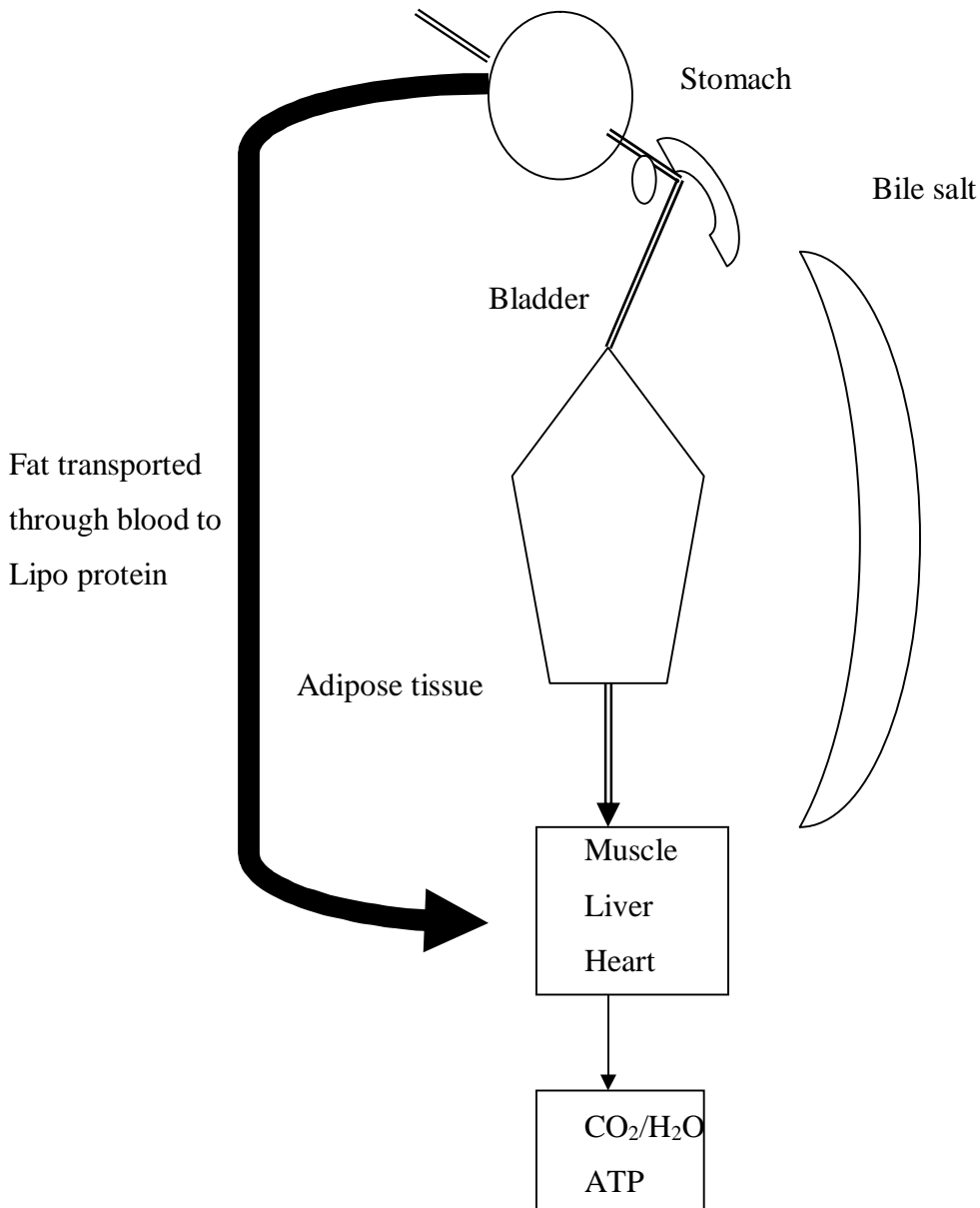
The product of fat digestion is a mixture of free fatty acids (FFA), mono and diacyl glycerol. During the absorption through the mucosa cells, some of these products from hydrolysis condense to re-synthesize triacyl glycerol. This is known because much of the absorbed lipids is in form of triacyl glycerol complexed with protein, sometimes it can

form complexes with cholesterol and sometimes complexes with phospholipids. When it forms complex with protein, it is called lipoprotein. When it forms complex with cholesterol, we call it chylomicrons or portomicrons.

Fats are derived from 2 primary sources in the body;

- a. The diet
- b. Mobilization of fat stored in the adipocytes.

OVERVIEW OF FAT DIGESTION AND ABSORPTION



After absorption of lipids, it can be associated with protein to form lipoprotein which aid in the transportation of lipid for energy storage. The lipoprotein are synthesized mainly in the liver. Lipoproteins are classified according to their density into;

1. Chylomicrons
2. Very low lipoprotein
3. High density lipoprotein
4. very high density lipoprotein

MOBILIZATION OF FAT

The release of energy stored in the fat is comparable to the mobilization of carbohydrate stored in animal glycogen. The steps involved are;

STEP I: Activation of adenylate cyclase epinephrine.

STEP II: Active adenylate cyclase in turn activates protein kinase by phosphorylation.

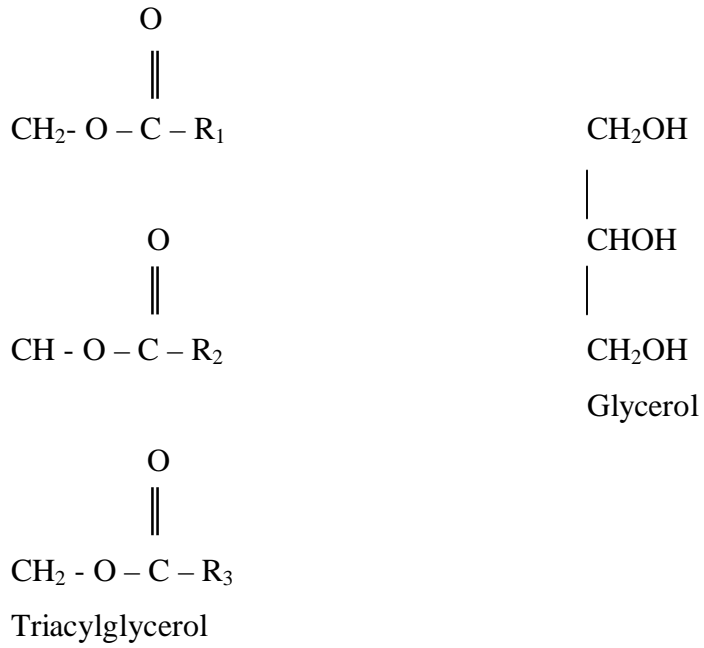
STEP III: Active protein kinase activates an enzyme called triacyl glycerol lipase.

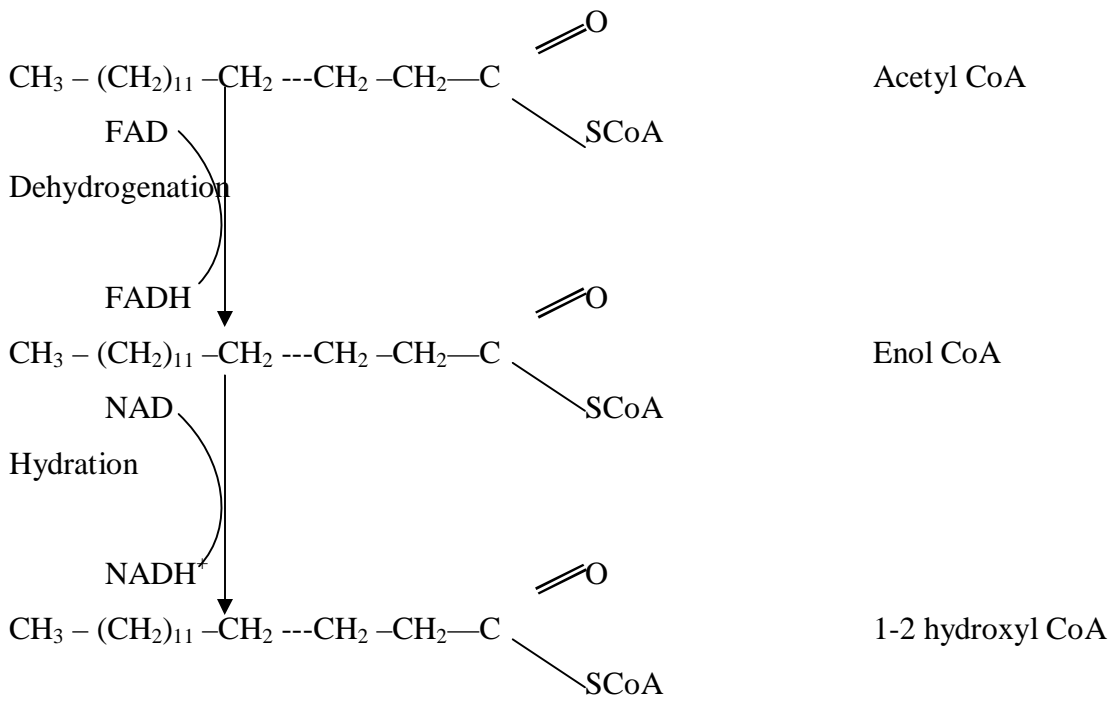
STEP IV: This enzyme catalyses hydrolytic released of fatty acid from carbon 1 or 3 of the glycerol.

STEP V: The fatty acid released is followed by the action of a di and mono acyl glycerol lipase. These three enzymes degrade the original molecule to glycerol and 3 un-esterified fatty acid.

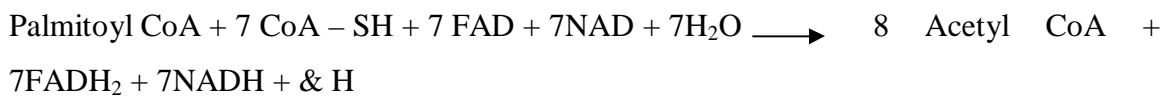
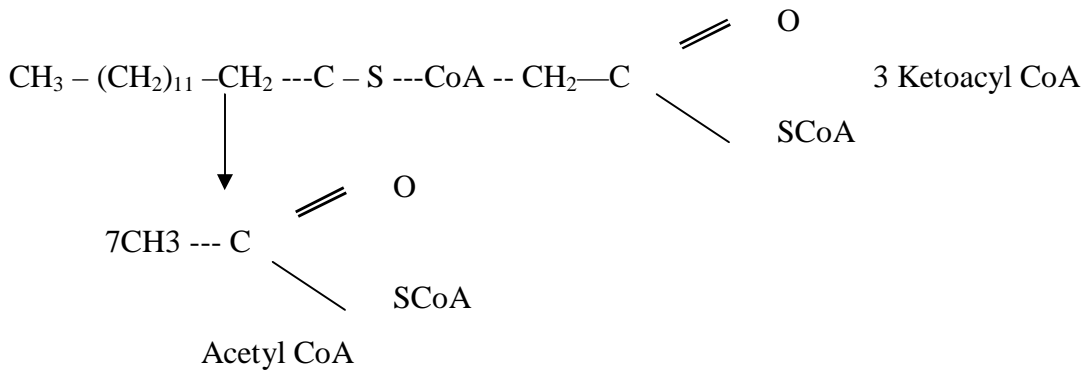
The hormones are mediated by epinephrine in stress situation and it is also mediated by glycogen during fast.

FATTY ACID OXIDATION OF PALMITYL CoA



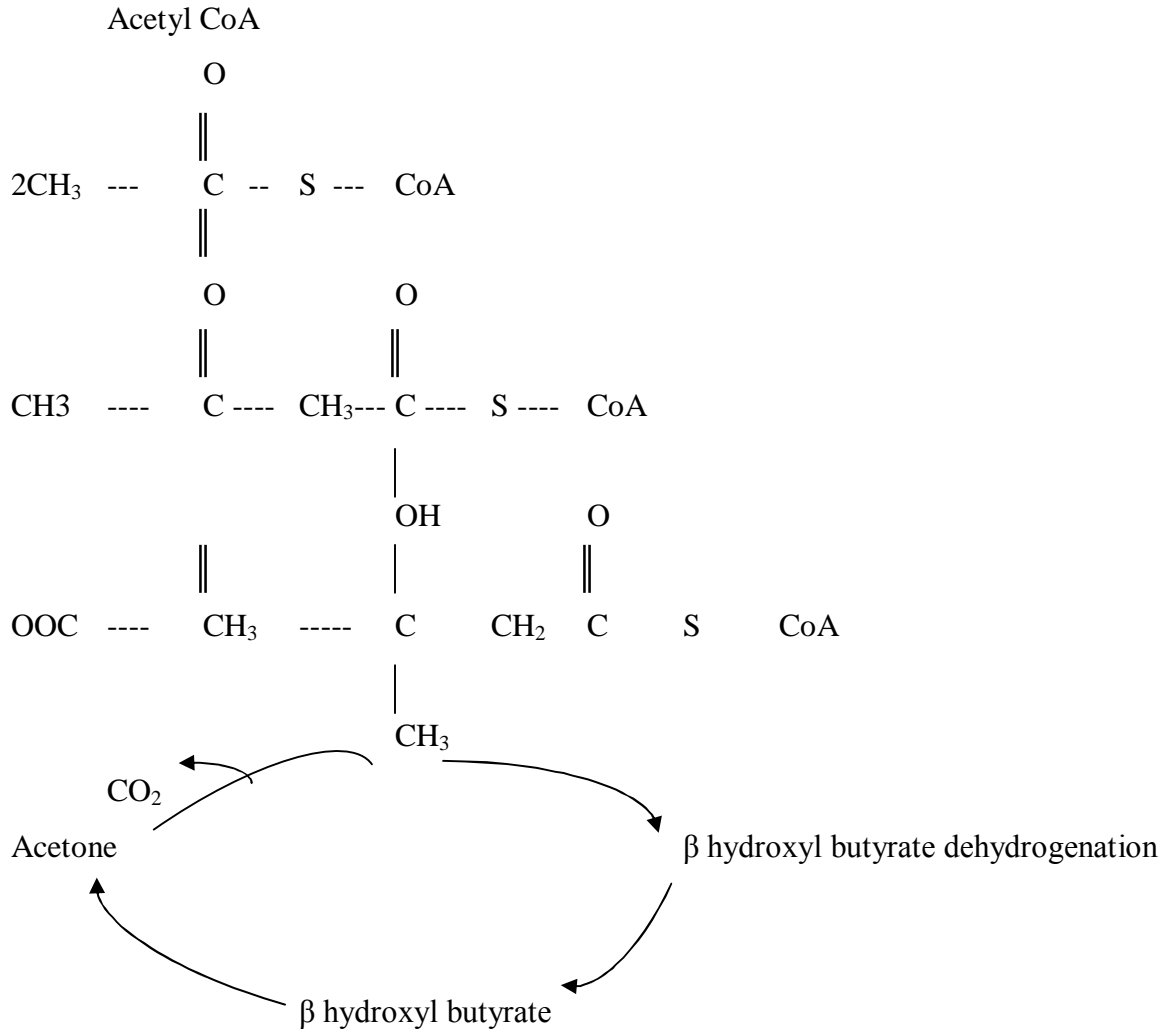


Dehydrogenation



| Reactions | ATP yield |
|--|----------------|
| Activation of Palmitoyl CoA | -1 |
| Oxidation of 8 Acetyl CoA 8 x 12 | 96 |
| Oxidation of 7 FADH ₂ 7 x 2 | 14 |
| Oxidation of 7 NADH 7 x 3 | 21 |
| | 130 ATP |

CHAINS OF KETOGENESIS



When FADH is been dehydrogenated, it will be converted to flavine adenine dinucleotide hydrogenase likewise NAD.

NOTE: Acetyl CoA is 8 times because molecule of fats gives 130 ATP that is why fatty acid gives a higher energy than carbohydrate.

Catabolism of fats begins with hydrolysis of triacylglycerol to yield glycerol + 3 molecules of fat comes from fatty acids with 5% of glycerol. Most of the fatty acids arise in the cytosol, either through biosynthesis or through triacylglycerol transported from fats depot outside the cell. There is a formation of acyl CoA made up of long chain of fatty acids instead of 2 carbon acetic acids. The endoplasmic reticulum at the outer membrane of mitochondria uses this as fuel within the mitochondria, these reactions are catalysed by carnitine acyl transferase which transverse within the inner membrane. The oxidation of fatty acids is a series of steps in which each step release 2 carbon fragments

in form of acyl CoA the pathway is cyclic which involves 4 reactions and ends with the formation of acyl CoA short ended by 2 carbon which undergoes the same process in the next step.

e.g. Palmitoyl CoA undergoes 7 cycles of oxidation to form 8 molecules of acetyl CoA. Each cycle release 1 -2 carbon units with 2 electrons.

Oxidation of saturated fatty acyl CoA involves the following reactions:

1. dehydrogenation to form Enol CoA
2. Hydration of the double bond forming 1,3 hydroacyl CoA.
3. Dehydrogenation of the hydroxyl group to form 3 ketone CoA
4. Cleavage of the 2nd molecule co-enzyme to release acyl CoA.

KETOGENESIS

Acetyl CoA has 2 metabolic fates;

1. Oxidation to CO₂ in the TCA cycle
2. Biosynthesis of fatty acid

Another major pathway comes into play in the mitochondria when acetyl CoA accumulate beyond its capacity to be oxidized or used for fatty acid synthesis. That pathway is called ketogenesis and it leads to a class of compounds **called Keton bodies**.

BIOENERGETICS

Foods are needed for synthesis of products in the body. They are needed as source of energy. Foods are involved in the transfer of energy such as when chemical energy is converted to mechanical energy of heat. The ability of a food to supply energy is therefore of great importance in determining its nutritive value.

Energy is needed for mechanical work (i.e muscular activities), for chemical works such as movement of substance against concentration gradients, synthesis of enzymes and hormones.

When the chemical energy of the food is used for muscular and chemical work involved in body maintenance, the animal does not work on its surroundings and the energy used is converted to heat. In fasting animal, the quantity of heat produced is equal to the energy of the tissues catabolised. Energy supplied by the food in excess of that needed for

maintenance is used for various forms of production. A young growing animal will store energy principally in the protein of its new tissues whereas an adult will store relatively large energy in fat. Whereas, a lactating animal will transfer food energy into energy contained in milk constituent.

TYPES OF ENERGY

1. **Heat Energy:** This is the energy produced only to keep the body warm. Its production is taken into account in measuring the efficiency of body processes. The basic unit of energy is called Calorie (Cal). A calorie is defined as the amount of heat energy required to raise 1g of water from 14.5°C to 15.5°C. This is small, hence in practical nutrition a large calorie is used i.e Cal.

Calorie (Cal) is defined as the amount of heat energy required to raise 1 kg of water by 1°C.

2. **Gross Energy:** When a substance is completely burnt to its ultimate oxidation product i.e CO₂ and water and other gases, heat is given off and that heat is referred to as Gross energy. The quantity of heat resulting from complete oxidation of a unit weight of food is known as Gross energy. Gross Energy (G.E) is sometimes called heat of combustion.

The oxidation of hydrogen and carbon atom in food leads to gross energy. CH₂O have enough oxygen in the molecule to oxidize the hydrogen. Hence the only produced heat is from the oxidation of carbon.

In fats, less oxygen is present in the molecule hence heat is produced from the oxidation of carbon and hydrogen. This gives the reason why the heat produced in fat is higher than CH₂O.

In protein, heat is generated also from the combustion of carbon and hydrogen but the nitrogen that is present in protein gives rise to no heat at all since it is set free as gaseous form. The gross energy value of the 3 classes of feed ingredients is stated below;

CH₂O = 4.15Kcal/g

Protein = 5.65Kcal/g

Fat = 9.4 Kcal/g

3. **Digestible Energy:** Apparent digestible energy of a food is the gross energy content of a weight of the food less the gross energy content of faeces resulting from the consumption of a unit weight of that food. Apparent digestible energy is the energy generated from the food minus the energy generated from the faeces.
4. **Metabolisable Energy (M.E):** M.E of a food is the digestible energy less the energy lost in the urine less the energy lost in combustible gases. Energy in urine is present in nitrogen containing substances such as urea, allantoin, uric acid, hippuric acid, creatinine, glucuronate. The combustible gases lost from rumen consist of methane. Methane production is directly proportional to food intake.

At maintenance level of nutrition, 7-9% of G.E is lost as methane. For poultry, metabolisable energy is measured easily than digestible energy. Why? This is because in poultry the faeces and urine are mixed together so the M.E can be easily measured during the process.